RESEARCH PROGRESS

2000 Research Update

Agriculture and Agri-Food Canada

Agriculture et Agroalimentaire Canada

Lethbridge Research

Sustainability through

As one of Canada's largest and longest-serving public research institutions, the Lethbridge Research Centre takes pride in its research progress.

This progress, a direct result of a specific business strategy designed to be sustainable over the long term, is based on four key principles.

The first is leading-edge research. The Centre has some of the best scientific minds in agricultural research today and extensive facilities linked to Canadian and global research networks. That base of knowledge and technology will anchor progress over the long term.

To improve the long-term economic and environmental sustainability of the Canadian agri-food sector through the development and transfer of innovative technologies.

102-06970/

Centre

research progress

Second is value for the public good. Public research institutions have a direct responsibility to provide for the public good. The economically and environmentally sustainable agri-food research carried out at this Centre is committed to providing value for taxpayer investment.

Third is strategic partnerships. The Centre believes strength in today's globally-driven business environment comes from business and social partnerships. The Centre leverages its research resources by building strategic links with other research organizations, industry associations, companies and governments. The target is to be valued as a good business partner.

Finally, the Centre believes knowledge will build a sustainable industry. A significant effort is made to ensure the knowledge and technology produced at the Centre are passed on to industry and the general community.

This *2000 Research Update* is an example of that commitment. It provides an overview of the background, business focus, structure and operations of the Lethbridge Research Centre, and the research carried out over the past year.

Research serves Canada's public

Dr. Brian Morrissey, Assistant Deputy Minister, Research Branch, Agriculture and Agri-Food Canada

The studies carried out at the Lethbridge Research Centre are a strong example of the growing value to the Canadian public of publicly funded agricultural research.

As this *Research Update* outlines, this research is diverse and its benefits will ultimately touch every corner of Canadian society. That value has never been more evident than in today's globally driven, rapidly advancing world of food production and environmental sciences.

Today's general public is a direct partner in this process. More than ever before, that public is better educated, better informed and more interested in the world around them. They live in the information age and their expectations from the research community are high. They wish to understand what is being done and why, how it affects them personally, their families and their communities.

Across Canada, a network of Agriculture and Agri-Food Canada research centres is geared to progress on economically and environmentally sustainable food production. That effort is supported by increasing interest from the business community.

Good agricultural research makes good sense. It is a sound investment for the Canadian public, and one we are proud to share.

New facilities will anchor Centre growth

Dr. Steve Morgan Jones, Director, Lethbridge Research Centre

This coming year will see the start of a major construction project that will change the face of the Lethbridge Research Centre. Over the next two years, it will upgrade and retrofit existing research facilities and add about 30 percent more research space.

Included as part of this project are laboratory facilities for insect quarantine, which will expand the range of studies on non-chemical control of weeds. There will also be a considerable expansion in modern greenhouse space to accommodate a growing number of studies that require controlled environmental conditions, as well as additional science laboratories.

The project represents an investment of approximately $21 million and illustrates the importance that the Federal Government places on the need for advanced agricultural technology and sustainable food production.

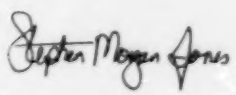
During the past year, there has been growing public debate on several issues related to agriculture. The use of genetically modified crops has been daily news in Europe and has been featured on a regular basis in the Canadian media. The Centre is conducting research on genetically modified plants to develop non-chemical approaches to disease resistance, while maintaining the traditional plant breeding programs that have served the industry so well.

The future of biotechnology is very much linked to furthering knowledge on how plant and animal genes function so that selection for improved crop or animal performance can be conducted more rapidly and cost-effectively. The Centre will also begin a study in 2000 to determine the environmental impact of growing genetically modified crops over a number of crop years.

Environmental concerns have surfaced with respect to intensive livestock operations and their potential impact on air and water quality. Studies have been underway for several years and are due for completion in 2001. A large collaborative study has been initiated with the University of Calgary and Feedlot Management Services in Okotoks to determine if the use of antibiotics in cattle feeding results in bacteria that are resistant to antibiotics used in human medicine. This is an expensive study that is fully financed by the cattle industry (Canada/Alberta Beef Industry Development Fund) and will provide answers to very important questions.

The Centre continues to develop partnerships with other institutions and the private sector. Strong relationships with Canadian and U.S. universities and a special relationship with the University of Lethbridge, allow a number of scientists to function as partnership professors and participate fully in teaching programs. In 1999 the ongoing relationship between the Centre and Alberta Agriculture, Food and Rural Development staff was formalized through the signing of the Sustainable Beef Research Alliance. Partnerships have steadily increased since the introduction of our Matching Investment Initiative program in 1995. Partnerships increase the scope of the work, reduce duplication of effort and help move research results into the hands of the user group in a timely manner.

We hope you will find the contents of this *Research Update* useful and informative. The research results describe, in summary, some of the important findings from our programs. We would be pleased to receive your comments on this report and can provide further information on topics of interest.



Lethbridge Research Centre Management

Led by science, guided by industry need and public good.

The Lethbridge Research Centre is headed by the Centre Management Committee, comprised of management and section heads. The Centre Management Committee determines direction, with advice from Agriculture and Agri-Food Canada leadership and the Centre's own Advisory Committee - a diverse group of third party public and industry representatives.

Centre Management Committee

Dr. Steve Morgan Jones
Director
Phone: (403) 317-2200
Email: morganjoness@em.agr.ca

Dr. Peter Burnett
Assistant Director
Research Programs and Facilities
Phone: (403) 317-2202
Email: burnettp@em.agr.ca

Dr. Glenn Coulter
Assistant Director
Commercialization and
Communications
Phone: (403) 317-2210
Email: coulter@em.agr.ca

Dr. Zahir Mir
*Acting Head, Crop Sciences
Phone: (403) 317-2243
Email: mir@em.agr.ca

*New Head effective Sept.1
Dr. Jeff Stewart
Head, Crop Sciences
Phone: (403) 317-2208
Email: stewartj@em.agr.ca

Dr. Rick Butts
Head, Land Resource Sciences
Phone: (403) 317-2265
Email: butts@em.agr.ca

Dr. Brian Freeze
Head, Livestock Sciences
Phone: (403) 317-2241
Email: freeze@em.agr.ca

Marc Parent
Head, Administration
Phone: (403) 317-2204
Email: parent@em.agr.ca

Commercialization and Marketing Group

The Centre's in-house Commercialization and Marketing Group manages business partnerships, transfers commercial technology and protects intellectual property rights. The Group is designed to leverage the Centre's position as a producer of technology and leading edge agricultural research to benefit industry and the public.

Centre Advisory Committee

The Centre Advisory Committee consists of volunteers from industry, universities, the Provincial Government and the local community, who assist the Centre management in planning the research programs. The Committee meets twice a year to review ongoing programs and overall research direction. The Centre Advisory Committee members are listed on page 23.

Canada/Alberta Livestock Research Trust Inc.

The Canada/Alberta Livestock Research Trust Inc. (CALRT), in support of the Lethbridge Research Centre, owns all livestock that the Centre uses in its research programs. CALRT, through its industry Board of Directors, provides direct financial support and advice for livestock research. In the past year, CALRT has fully funded the construction of feed silos and has made a direct contribution to the Lethbridge Research Centre communications program. The members of the CALRT Board of Directors are listed on page 23.

Lethbridge Research Centre facilities

Established in 1906 as a Dominion Experimental Station, today the Centre employs 400 full, part-time and seasonal staff, including approximately 80 scientists.

Main Centre facilities

The Lethbridge Research Centre is one of western Canada's oldest public research institutions. Today the Research Centre consists of a 25,000 square meter laboratory and office complex, and 500 ha (1,190 ac.) of adjacent land.

The Centre has extensive research facilities in crops, soils and ruminant livestock. The beef unit facilities have capacity for 1,635 head. Included is a 285 head barn which allows specialized feeding of individual animals, a dairy and beef metabolism barn, a 1,000 head capacity feedlot with 48 small pens and four large pens, as well as several beef barns.

Dairy facilities include 275 head capacity with a main barn, calf barn, loose housing and dry barn. Sheep facilities include a research barn, pens and isolation building for using sheep in ruminant model studies. A state-of-the art feedmill provides a backdrop to nutrition studies. Animal parasitology facilities include a controlled environment building, feedlot and holding paddocks.

The Centre has specialized biocontrol facilities that include insect rearing rooms, insect quarantine facilities, a microbial culture centre, and extensive greenhouse and laboratory space. Additionally, a series of long-term cropping rotation studies both irrigated and dry land were established as early as 1910.

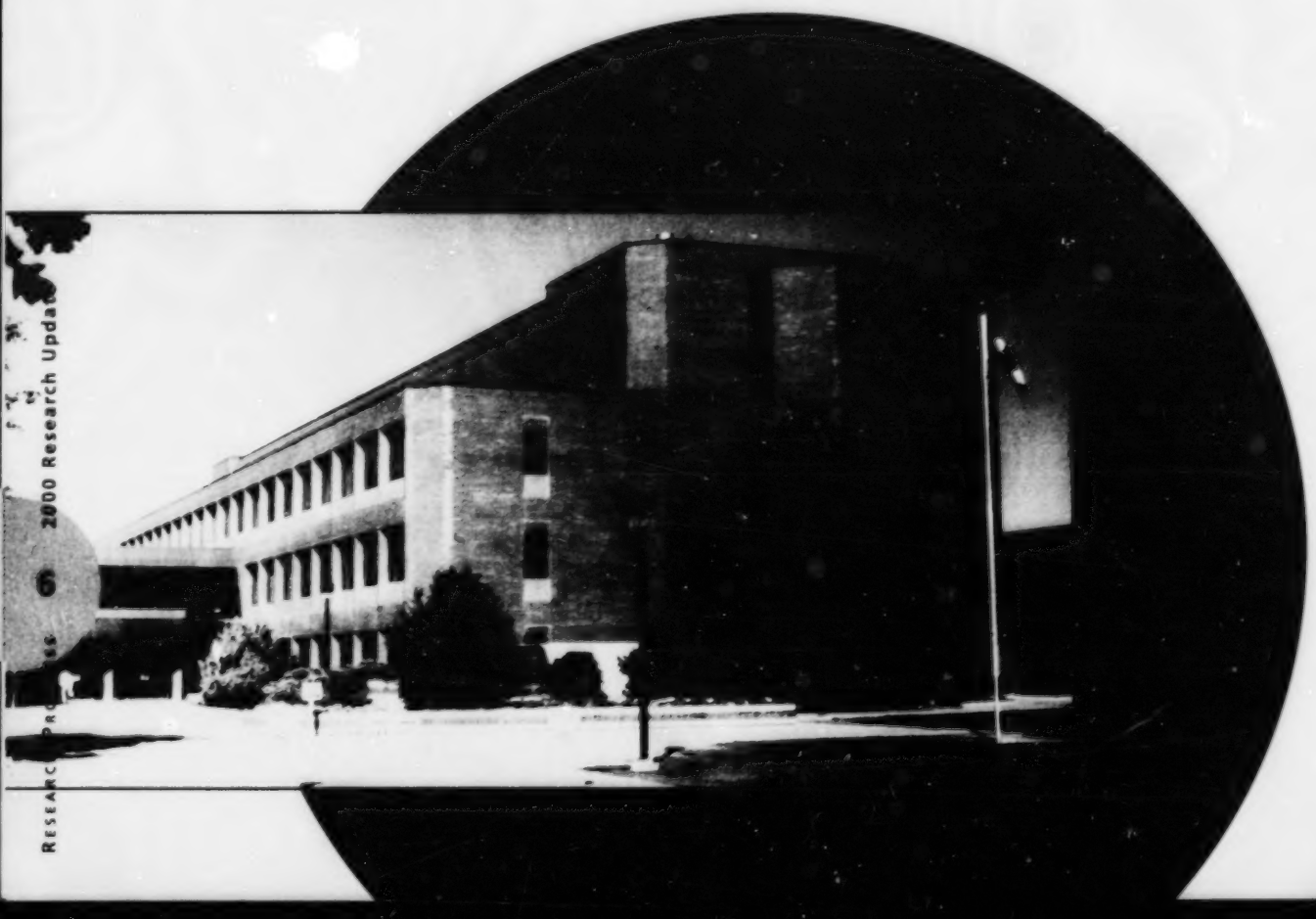
Affiliated research sites

The Kamloops Range Research Unit. British Columbia's major site for range research, the Kamloops Unit was administratively linked with the Centre's range management program in 1993. The Kamloops Unit includes laboratories and 23 ha (57 ac.) of mostly irrigated pasture for growing legumes and grasses. Research is also conducted at the Pass Lake Range site which includes 500 ha (1,230 ac.) of forested rangeland and 40,000 ha (98,400 ac.) of Crown grass and forested grassland.

Onefour Ranch. A 17,000 ha (42,000 ac.) shortgrass prairie range research site near Manyberries, Alberta is the Centre's main site for cattle genetics and breeding research as well as range management studies. It is home to a 200 cow Angus herd and a 200 cow Charolais herd. Both are owned by the Canada/Alberta Livestock Research Trust Inc. – a unique partnership between the Lethbridge Research Centre and Alberta beef, sheep and dairy producers. Set up as a non-profit, livestock industry driven research trust, all revenues from the sale of the livestock and their by-products are reinvested in the Lethbridge research program.

Stavely site. A 390 ha (960 ac.) site for rough fescue range research.

Vauxhall site. A 190 ha (480 ac.) site for potato, soft white wheat and rotation research.

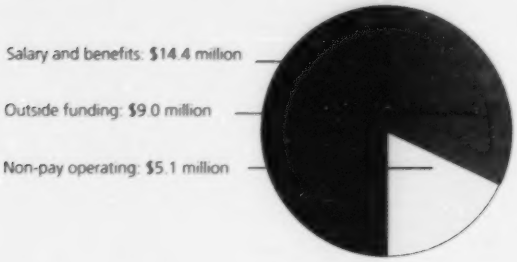


Centre business activity

The Lethbridge Research Centre approaches science in a business-like manner to serve its public and private investors. A focus on sound strategic planning, innovation and creativity is reflected in the Centre's growing use of outside funding and initiatives such as the creation of the Commercialization and Marketing Group.

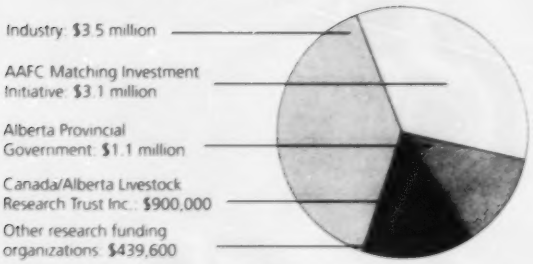
Operating budget 1999-2000

Total budget: $28.5 million



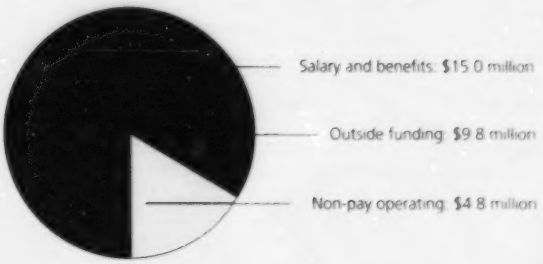
Outside funding 1999-2000

Total outside funding: $9 million


Industry: $3.5 million
AAFC Matching Investment Initiative: $3.1 million
Alberta Provincial Government: $1.1 million
Canada/Alberta Livestock Research Trust Inc.: $900,000
Other research funding organizations: $439,600

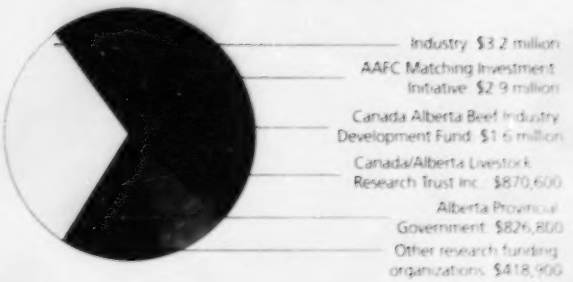
Projected 2000-2001 operating budget

Total projected operating budget: $29.6 million



Projected 2000-2001 outside funding*

Total projected outside funding*: $9.8 million


Industry: $3.2 million
AAFC Matching Investment Initiative: $2.9 million
Canada Alberta Beef Industry Development Fund: $1.6 million
Canada/Alberta Livestock Research Trust Inc.: $870,600
Alberta Provincial Government: $826,800
Other research funding organizations: $418,900

*Figures may change throughout year. Outside funding will increase as the year progresses.

Research structure and progress

The Centre is comprised of three research sections: Crop Sciences, Land Resource Sciences and Livestock Sciences. Several core research priorities are established within each section. A progress report on research activity follows.

Livestock Sciences Section

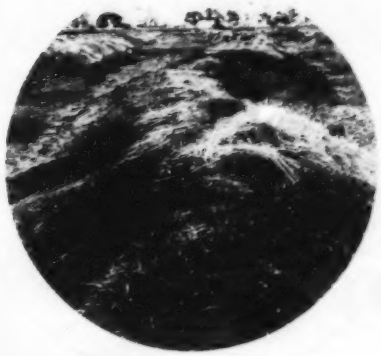
- pest management
- genetics and physiology
- ruminant nutrition
- feed microbiology and biotechnology
- bioeconomics

Lethbridge is designated as the Federal Centre of Excellence for beef cattle research.

Land Resource Sciences Section

- range management
- waste management
- water quality
- soil quality
- remote sensing, GIS
- economics

The Land Resource Section has a prairie-wide mandate for sustainable production and water quality.



Crop Sciences Section

- new cultivars in wheat (winter and soft white wheat), beans, potatoes and forages
- disease resistance
- cropping systems
- weed biocontrol

The Crop Sciences Section has a prairie-wide mandate for the development of sustainable cropping systems and germplasm.

Feed microbiology and biotechnology

New tools to expand production margins

The feed additives program is designed to tap the immense economic potential of feed efficiency gains.

Pathways to controlling AIP. Scientists identified 3-methylindole as a possible causative agent of Acute Interstitial Pneumonia (AIP) in feedlot cattle. Although others have proposed that Bovine Respiratory Syncytial Virus (BRSV) plays a role in the development of AIP, Centre researchers found no evidence of this virus in any of the animals they studied. It is becoming more apparent that AIP in southern Alberta feedlots may arise from a complex interaction of feed intake, feed composition, individual animal physiology, and possible environmental triggers. With 3-methylindole identified as the likely problem, researchers now have a target to implement dietary or management practices that may provide cattle with a measure of protection from the disease. Part of the plan will be to explore the potential of management practices such as controlling dust, increasing the level of cysteine in the diet, and providing elevated levels of vitamin E as an antioxidant.

Improving the nutritional value of rumen-synthesised protein. Most of the protein available to cattle doesn't come from the food the animal eats - it's produced by microorganisms in the animal's rumen. Unfortunately, ruminally synthesized microbial protein doesn't meet the animal's protein needs efficiently because it doesn't have the correct balance of essential amino acids. Producers meet the protein requirements of highly productive animals only at considerable expense, by feeding large amounts of dietary protein or by feeding protected proteins or amino acids. New proteins have been designed, which have a very high content of essential amino acids and can be produced by rumen microbes, allowing the protein produced in the rumen to meet the animal's needs. The protein will be protected by the microbe from degradation in the rumen but will still be completely digested in the intestine. The main advantages of this approach over the use of either normal or protected dietary proteins or amino acids would be lower overall production costs and lower environmental impact.

Bacteriocins as ionophore alternatives. Bacteriocins are antimicrobial proteins produced by bacteria. The production of bacteriocins, coupled with resistance to bacteriocins produced by other bacteria, allow a bacterial strain to colonize an environment and exclude competing bacteria. Many bacteriocins act through a mechanism similar to the ionophores that are used extensively as feed additives in the beef, and increasingly, in the dairy industry. Among their effects are improved production efficiency, reduced methane production, and (in dairy cattle) reduced milk fat production and improved milk fat composition. A large number of bacteriocins produced by rumen bacteria have been identified. Many of the rumen bacteriocins have a range of activity that mimics that of the ionophore antibiotics, which suggests that they would be effective alternatives to the ionophore antibiotics for the modification of rumen microbial populations and fermentation products. Bacteriocins also have many advantages over existing ionophores. Their differing structures allow problems of developing resistance to be overcome, their complete digestibility (as proteins) prevents accumulation of residues, and their ability to be produced by natural bacteria in silage, or in the rumen itself, allows very low cost delivery. In addition, many of the rumen bacteriocins are much more specific than the ionophores, promising the ability to target specific rumen microorganisms that are responsible for such undesirable rumen functions as feed protein digestion, methane production, or fat hydrogenation.

Delivering peptides and enzymes. Scientists continued working on yeast-based protection systems as a method of delivering biologically active proteins, such as enzymes and growth factors, to the small intestine of cattle. Traditional methods of protein protection, such as heat or formaldehyde are effective, but they damage the structure that biologically active proteins rely on for their activity. Expressing genes for these proteins within the cell wall of the yeast *Pichia pastoris* protects them from degradation by rumen microorganisms. Preliminary experiments show that non-culturable cells remain intact in clarified ruminal fluid and water for over 24 hours. Ongoing studies are investigating live cells in ruminal fluid, and using specific growth and storage conditions (e.g., freeze drying) to increase the efficacy of this yeast system for post-rumen delivery.

Targeting rumen protozoa. This ongoing study established that cattle fed high-barley diets have sizable, diverse protozoa populations in the rumen. Since these microbes reduce available protein in cattle nutrition, scientists are testing a number of compounds - including saponin-containing plants, ionophores, fatty acids and surfactants - to limit rumen protozoa without affecting rumen bacteria, which would increase the efficiency of protein use in cattle. Vegetable oils are being tested for a dual purpose: to limit protozoa and to increase the content of desirable conjugated linoleic acid in meat.

Diversity of rumen bacteria. New molecular-based techniques revealed that the diversity of bacteria in the rumen is far greater than previously known. By comparing DNA sequences, scientists found several types that indicate a large number of new and potentially important bacterial groups remain to be discovered. These include groups of methane-producing bacteria and fibrolytic bacteria. Researchers have developed molecular probes for common rumen bacteria and are developing probes to identify and quantify the new groups.

Bovine Epidermal Growth Factor. Researchers took a first step toward developing a new feed additive. They made significant progress toward identifying the gene segments responsible for producing Bovine Epidermal Growth Factor (EGF), an inexpensive feed additive that could enhance nutrient absorption and promote general intestinal health.

Reducing phosphorus pollution. A gene has been cloned from a particularly vigorous rumen bacterium that is capable of releasing the phosphorus in feed that was previously unavailable to the animal. The enzyme degrades phytate, which is a major storage form of plant phosphorus. The gene has been cloned into expressions systems that are capable of producing large amounts of the enzyme for evaluation in poultry feeding experiments. Studies are now characterizing the activity of the gene and whether it is altered when produced in yeast expression systems. Present results indicate that the enzyme will reduce the need for phosphorus supplementation in poultry and swine.

Antibiotic resistance. Studies have been initiated to determine the effect of administration of subtherapeutic levels of antibiotics on the development of resistant bacteria in the digestive tract of feedlot cattle. The antibiotics are being removed and added to diets at specific times during the feeding period to determine if management practices can be used to curtail the development of resistant populations. Work in the coming year will examine mechanisms of resistance transfer in bacteria. Resistant populations that develop in cattle are being compared to microbial populations in feedlot workers as well as the

general public, to determine if there is a relationship between development of resistant microbial populations in cattle and humans.

Molecular relatedness of anaerobic fungi. As part of ongoing work with anaerobic fungi, molecular techniques were utilized to help establish a phylogenetically-based taxonomic system. Traditional taxonomy of these fungi is based on a few gross morphological features and is subject to considerable subjectivity. This system is recognized as inadequate and has hampered a basic understanding of the role played by the different genera of anaerobic fungi in ruminal digestion. Current work should be of great benefit in resolving some of the existing confusion in the taxonomy of the anaerobic fungi and prove invaluable to both those studying enzyme systems and the ruminal ecology of these fungi.

Pathogens in manure and the environment. To address growing concerns about the environmental effects of intensive livestock operations, an ongoing cross-disciplinary study focuses on key environmental parameters. Research in the program has focused on the presence and persistence of potential microbial pathogens, such as *Escherichia coli, Giardia sp.* and *Cryptosporidium sp.* in manure and the environment, using both direct counts and indicator microbes. By addressing this issue head-on, researchers hope to minimize possible detrimental environmental effects of the livestock industry.

Improving fibre digestion. As part of ongoing studies of the microbial digestion of fibre, researchers have obtained access to ruminal and fecal samples from muskox kept on native range. The isolation of fibrolytic bacteria and fungi from these animals subsisting on poor quality diets has the potential to provide new, highly active microbes and enzymes. Potential differences in the ecology of the muskox versus cattle rumen may also highlight key factors in increasing the utilization of poor quality fibre in cattle.

Nutrition and management

Strategies for optimal performance, health, efficiency and product quality

Nutrition is a core factor in all aspects of livestock production. Scientists are developing nutritional strategies that improve the use of feed to both benefit the animal and improve production, while minimizing feed costs and environmental impacts.

Bunk management technology. Computerized systems have been developed to monitor feeding behavior and measure intake in feedlot cattle. An antenna in the feed bunk detects electronic ear tags on each animal, allowing a computer to record the time, location and duration of each bunk visit. A second system marries this technology with a feed bunk that is suspended on load cells to measure on a continuous basis the amount of feed that is consumed by each animal in the pen. The system demonstrated that there was no value in including an older cow to train calves when they first enter the feedlot to consume feed and water. The system documented that the cow did not feed with the calves and actually detracted from feeding in the first week of the feeding period. Complicated database systems are presently being developed to deal with the large volume of data generated by the feeding behavior and intake systems. Undoubtedly, this system opens the door to developing new feeding management strategies for feedlot cattle. The goal is to determine optimum feed intake which results in minimum feed costs and maximum performance.

Yucca plant benefits. Preliminary results from this study showed that an extract from yucca plants can help control undesirable parasites and improve nitrogen metabolism in the rumen. The extract allows for better use of nitrogen by the animal. This means less nitrogen excretion and more nutrients available. Potentially, it can reduce protozoal numbers in the rumen, improve ruminal protein metabolism and improve the balance of rumen microbial populations. An industry partner will pursue the commercial use of the extract.

Feed enzymes for cattle. The Centre has collaborated with several industry organizations and companies in the development of new feed enzyme technology to improve feed utilization in cattle diets. The Centre has patented a method of adding enzymes to cattle diets, which allows the enzymes to break down fibre in forage and grains in the animal's rumen. The result is that cattle can extract more nutrients from the diet, thereby achieving greater efficiency, which significantly enhances production performance. The patented technology was licensed this past year to an industry partner. Canadian cattlemen and dairy producers now have commercial access to this product. Basic research conducted by the Centre during the development of this new product is expected to result in additional products and management practices that will benefit Canadian cattlemen in the future.

Managing rumen acidosis. Feeding for maximum productivity has increased the incidence of subclinical rumen acidosis both in feedlot cattle and in dairy herds. Subclinical rumen acidosis occurs when the degree of acidity (measured as pH) in the rumen declines below optimum for fibre digestion by the rumen bacteria. Subclinical acidosis differs from acute acidosis, in that cattle remain alert and mobile and continue to eat. But acidosis causes large financial losses due to increased feed costs resulting from poor fibre digestion and lower feed efficiency. While there are no figures on the incidence of rumen acidosis in western Canada, studies conducted at the Centre have observed that cattle fed barley have a lower rumen pH than cattle fed corn. Rumen acidosis occurs when the production of fermentation acids in the rumen exceeds the ability of the animal to remove or neutralize the acids produced. Strategies to prevent rumen acidosis include: avoid abrupt dietary changes, provide a total mixed ration, encourage small frequent meals, and balance the intake of barley starch with the proportion of forage in the diet, forage particle size and dietary buffers.

Nutrient management. A study was initiated to track the nitrogen and phosphorus balance of an entire feedlot system. The research is expected to result in a new model to help cattle producers reduce costs and reduce environmental impact by optimizing nutrient use in their operations. The model looks at pathways of nitrogen and phosphorus right from cattle feeding through to application to the crop and

finally crop uptake. Losses to the atmosphere or water bodies at any point in the system will also be quantified. The goal is an easy-to-use computer model that feedlot operators could use to make decisions based on actual data from their operations. By fine-tuning the feeding and cropping strategies, the model would help cattle producers optimize nitrogen and phosphorus utilization, which should result in maximum cost savings with minimal environmental impact.

Alternative sources of fibre. Studies were conducted to determine the potential of using alternative fibre sources in feedlot cattle diets in order to reduce the amount of silage required. In one study, up to 9 percent beet pulp was added to the diet without negatively affecting intake, growth rate or feed efficiency of cattle. This translated into an increase in net return per head, and more importantly, reduced the amount of barley silage used by 30 percent. In subsequent studies, beet pulp was used as a total silage replacement. In those studies, two percent of the diet as chopped straw (and urea) was used along with the beet pulp to ensure adequate rumen function. Using a combination of beet pulp and straw rather than silage, improved rate of gain of cattle by 17 percent and feed efficiency by 14 percent, without affecting carcass quality. Cost of gain was lowered by $0.15 per kilogram, which, for a 20,000 head feedlot, represents a $600,000 reduction in feed costs over the feeding period.

Rumen-protected amino acids. New amino acid supplements that bypass the rumen may offer a more sustainable, low-cost alternative to commercial bypass protein supplements, studies show. In basic dairy rations, only about 30 percent of feed protein reaches the small intestine for processing. Many dairy producers supplement feed with bypass protein products, also known as undegradable intake proteins, to get more protein through the rumen. However, the studies indicate that using rumen-protected amino acids can produce the same benefits with more efficiency. Rumen-protected amino acids are relatively new and are expected to become widely available over the next few years. Containing regular amino acids or their analogs, they have a unique ability to pass through the rumen intact. That characteristic is critical, because most unprotected amino acids degrade quickly in the rumen before reaching the small intestine where they can be absorbed.

Conjugated linoleic acids for consumer health. Scientists found that adding canola oil to goat diets increases the conjugated linoleic acid (CLA) content of the milk, resulting in healthier milk for consumers. CLAs are derived from linoleic acid and mitigate the effects of undesirable fatty acids and have other health benefits. CLAs have been shown to stimulate the immune system, protect against heart disease and may have a role in preventing cancer. CLAs increase the level of healthier fatty acids and reduce those linked to cholesterol. Ongoing studies are investigating the potential of increasing the CLA content of beef and milk.

Rumen protozoa. Investigation continued into the relatively unknown roles of various protozoa in the rumen as the first step toward a "protozoa recipe" to improve the efficiency of feed use. Research suggests protozoa have a significant effect on several aspects of rumen digestion. Controlling protozoa levels could improve everything from milk yield and quality, to secondary factors such as methane reduction. Protozoa are generally negative because they ingest valuable proteins before cattle can use them and their activity increases methane production. But for certain protozoa, those effects are low and are outweighed by the species' positive effects on stabilizing rumen pH, contributing to dietary fibre digestion and helping prevent acidosis.

Effective fibre. Scientists determined the effective fibre value of forages can be used to adjust the proportion of forage in cattle diets to compensate for differences in chop length. This is important because the key to getting more mileage from grain and forage in cattle diets is supplying an adequate amount of coarse fibre to maximize digestion and rumen function, and because the optimum amount of forage in cattle diets depends on particle length. Longer forage particles provide effective fibre, which promotes rumination. In a survey of barley silage from feedlots and dairies in Alberta, the effective fibre values averaged 63 percent, ranging from a low of 45 percent (fine) to a high of 85 percent (coarse). When harvesting barley silage, the silage must be chopped sufficiently fine to maximize fermentation within the silo. The key is to measure the particle length or effective fibre content after ensiling and adjust the rations accordingly.

Nutrient absorption. Strategies for maximizing nutrient absorption are continually being developed. Strategies are based on Centre data concerning the factors that affect nutrient absorption in the small intestine. The data show the influence of various intestinal parameters on the performance of various breeds of cattle.

Beef tenderness. In this study, the effects of nutritional modifications on carcass and meat quality were determined. The results will help develop neural network models to predict beef tenderness from carcass measurements.

Intercropped barley/ryegrass. The study showed that feeding silage from intercropped barley and annual ryegrass to growing or finishing steers - with minimum amounts of barley grain - meets nutritional requirements for optimal performance from the animal. The intercrop also yields over 50 percent more than barley for silage under the same growing conditions. In a series of experiments, steers performed significantly better on barley/annual ryegrass silage than on barley silage. Dry matter intake, average daily gain, feed conversion efficiency and carcass weights all improved for backgrounded steers. The strong showing makes barley/annual ryegrass silage a valuable alternative for efficient beef production in barley-based diets. The study also serves as a basis for determining the minimum amount of grain needed in the diet to produce an acceptable beef product.

Wagyu benefits. Scientists continued to study Wagyu cattle to learn why their digestion system is so effective at directing food energy for deposition of fat within muscle - the process that produces well-marbled meat. Researchers are examining the biochemical characteristics of the breed to develop tools for recognizing marbling potential in cattle.

Forage specific inoculants. Silage inoculants have been developed for specific use in barley silage, the principal forage fed to feedlot cattle in Alberta. The inoculants improved nutrient conservation in the silage and enhanced digestibility when the silage was ensiled at later maturity. The study demonstrated that there is merit in the development of specific bacterial inoculants for specific forages.

Livestock pests

Moving toward sustainable controls

Thinking strategically is the key to pest control in the cattle industry, a concept that is reflected in the Centre's integrated approach to livestock pest management. Scientists are targeting strategies to help the beef industry adapt to new challenges by integrating long-term control alternatives that are economically and environmentally sustainable.

Horn fly diapause. Horn fly larvae must enter a state of arrested development called diapause in order to successfully overwinter and persist in colder climates. Researchers have identified the active DNA of diapausing pupae and are further studying its role to find ways of controlling diapause. They also initiated a collaborative research program with the USDA Kerrville, Texas laboratory, to examine gene regulation in diapausing horn flies.

Fly-microbe interactions. Scientists determined the effect of selected bacteria on stable fly larvae. Results showed that several species of bacteria are potential microbial controls of stable fly larvae, while others are used by the larvae for growth and development. The results will contribute to the development of bioassay procedures for evaluating the toxicity of bacteria used in microbial control programs against the stable fly.

Fly-microbe interactions. Five novel subspecies of *Bacillus thuringiensis* have shown enhanced activity against horn fly larvae, compared with standard *Diptera* specific strains. Current studies are examining the effect of these strains against stable fly larvae to determine the toxic components responsible for mortality.

Population modelling. Studies allowed researchers to separate post-diapause development from diapause development in population models. They also developed a model for simulating the spring emergence of horn flies. Results assist with simulation of control strategies for this pest.

Tick paralysis. Ongoing studies focus on identifying the toxin associated with tick paralysis. Tick paralysis affects humans and cattle in central B.C. A tick strain producing consistent paralysis has been identified and will be used to identify the toxin.

Cattle grub control. An ongoing study is evaluating recombinant antigens as components for a vaccine to protect cattle against cattle grubs. Variable results so far indicate that the structure of the recombinant protein is important in developing protective immunity.

Lice control. In collaboration with a large animal health corporation, researchers described the comparative efficacy of eight treatment protocols for managing lice. They also evaluated the persistent activity of five endectocides against controlled lice infestations.

Stress from biting flies. Scientists continued this study on how biting flies affect cattle stress. Using a model, they described the induction of conditioned analgesia caused by a stable fly attack and the neurochemical basis of sex differences. Researchers also measured changes in host behaviour induced by parasitism, which suggest coordinated management approaches are important for controlling pests and parasites.

Biocontrol of stable flies. Researchers evaluated the parasitic wasp *Muscidifurax raptorellus* as a biological control agent. This wasp is available commercially for controlling the stable fly and house fly. Parasitic wasps search out fly pupae and deposit eggs that produce larvae capable of killing flies as they develop inside the pupae. Results from the two-year study showed that this non-native species can travel as far as 100 m from the point of release to seek fly pupae, but has a very low overwintering survival rate. Therefore, fly control using this wasp depends on several releases each year. Parasitic wasps are very small (less than 2 mm), feed only on a select group of flies and are not harmful to people, plants, or animals.

New wasp for biocontrol. A province-wide feedlot survey revealed that the wasp *Trichomalopsis sarcophagae* is relatively abundant in Alberta, and has potential as a biological control agent. The wasp lays its eggs in the pupae of stable and house flies. The species can be readily mass-reared for release in feedlots and because it is native, it successfully overwinters in Alberta. Experiments showed that the wasp will seek fly pupae as far as 100 m from the point of release and that mass release in feedlots produced large, short-term improvements in fly control. Researchers will repeat these studies to provide more information on commercialization potential.

Endectocide effects on insects. Researchers initiated studies to follow up on previous research showing that the use of the product ivermectin can reduce insect activity in the dung of treated cattle, which can in turn reduce the natural rate of dung degradation. The new research will determine whether this is also true for three other endectocidal products on the market: doramectin, eprinomectin, and moxidectin. Results will provide cattle producers with the information necessary to select the most appropriate product for their needs.

Livestock physiology

Enhancing reproduction, growth and feed efficiency and quantifying stress

Understanding reproductive, nutritional and growth processes to increase long-term animal efficiency is the focus of physiological research. Researchers are also working on objective measures of animal stress and pain by studying blood hormone levels and animal behaviour.

Stress studies. A reliable means of objectively identifying the degree of stress resulting from management practices could save producers millions of dollars annually in production costs by identifying the practices that are detrimental to animal welfare so that they can be avoided or modified. Initial studies with sheep have indicated that the profiles of cortisol and b-endorphin responses to stress may be useful indicators of stressful events. Researchers are now in the middle of a 2-year project to determine an objective physiological indicator of stress in cattle. Both physiological and behavioral responses to stress are being examined to determine their usefulness as indicators of the degree of stress that various management practices cause in cattle.

Hormones in growth and marbling. A study using calves, both with and without Wagyu genetics, indicates that insulin is involved in fat deposition while cortisol and thyroid hormones are involved in muscle growth. Cortisol and thyroid hormones were significantly higher in calves with more marbling, indicating that these hormones may play a role in enhancing marbling in cattle. This basic research enhances knowledge of the role of hormones in energy partitioning and marbling in cattle and will be useful in developing research studies to improve growth rate efficiency and degree of marbling in beef cattle.

Bull fertility. Researchers studied scrotal and testicular temperatures and used ultrasound and infrared thermography in this ongoing study to predict semen quality and fertility in breeding bulls. Approximately 100 breeding bulls have been examined at artificial insemination centres. Researchers will examine links between physical measurement, temperature and ultrasound data, with changes in semen quality characteristics known to be influenced by shifts in environmental temperature. They are also measuring blood flow and oxygen delivery to the testes, to better understand the effects of increased testicular temperature on semen quality.

Suppressing reproductive function. Reproductive function in feedlot cattle disturbs feed intake and growth and makes animals more difficult to manage. Scientists used a novel vaccine to successfully suppress reproduction in both heifers and bulls. They also used an electronic mount detector to monitor feedlot heifers that were treated with methods of suppressing estrus, including both traditional (MGA in the feed) and novel (an intrauterine device) methods.

Synchronizing estrus and ovulation in cattle. Scientists built on their experience in synchronizing estrus in cattle by synchronizing ovulation, allowing for fixed-time insemination, with good fertility. These ongoing studies are being conducted on a larger scale under commercial conditions.

Embryo development. Reproductive failure due to embryonic mortality is a major cause of economic losses for beef producers. The production of embryos by *in vitro* maturation and *in vitro* fertilization of oocytes allows the study of embryos at the molecular level. One study is aimed at evaluating the effects of oocyte quality on gene expression during embryonic development. This work will contribute to a better understanding of embryo physiology and lead to the design of interventions aimed at reducing early embryonic mortality.

Oocyte maturation. The frequency of development of *in vitro*-produced embryos is still inferior to that obtained *in vivo*. One of the causes could be that nuclear maturation occurs spontaneously in cultured oocytes and this could prevent the accumulation of molecules important for early development. One study has identified a novel way to prevent spontaneous nuclear maturation in *in vitro* cultured oocytes. This has the potential to be integrated into *in vitro* embryo production systems and will provide a valuable tool to study the factors involved in the control of nuclear maturation.

New early life selection study. Researchers began this work to develop early-life selection criteria for female reproductive efficiency using ultrasound technology. The results will lead to models for further genetic improvement strategies.

Immunization protocols. A preliminary study was conducted to extract adipose membrane from slaughtered cattle for use as a vaccine. This is part of an ongoing effort to determine the effects of various active immunization protocols on cattle performance.

Beef cattle genetics

Optimal evaluation and improvement program

Improving Canada's cattle seedstock is the focus of a new, industry-driven approach to beef genetics research at the Centre. For decades, genetics research has focused on evaluation of different breeds and crossbreds in different environments and that work is essentially completed. The new focus is on improving genetic strategies for specific traits that are economically important to the industry.

Carcass merit. Researchers continued to evaluate real-time ultrasound (RTU) technology and other indicator traits as predictors of optimal carcass composition and meat quality. Accurate ranking of breeding-age bulls and heifers will lead to early-life indices of genetic merit for carcass traits. RTU may also be applied to prediction of waste fat in slaughter animals, to produce data which will be incorporated into improvement programs for overall carcass merit.

Feed efficiency. Studies are underway which utilize a novel computerized feedbunk system to measure individual feed intake and feeding behavior in group-housed cattle. Genetic control of feed intake and efficiency is not well understood, although most reports indicate that heritabilities are moderate to high and therefore selection for feed efficiency would be successful. Researchers are developing technology for measurement of feed intake and studies are underway to characterize its genetic control. Feed intake measures on slaughtered progeny will be used to develop genetic evaluation procedures and measure the genetic relationships among feed intake, feed efficiency and body composition. Feed intake data will also be collected on mature cows to estimate associations with reproductive performance and other measures of maternal ability.

Reproductive merit. Researchers continue to investigate evaluation programs for reproductive and maternal traits. Purebred bulls with high maternal EPD (Expected Progeny Difference) were mated via AI to estimate the effects of

selection for maternal EPD on reproductive performance. Researchers are also developing new, composite measures of maternal productivity which will combine stayability and other measures of herd life with production and performance.

Expected Progeny Difference (EPD) development. Efforts continue to focus on developing EPD for economically important traits. Increasingly sophisticated genetic models, data analysis tools and computing resources are used to improve accuracy and relevance of genetic evaluation methods which are the critical link between data and real genetic improvement. The ultimate goal is to improve the purebred or seedstock segment of the industry and improve the transfer of superior genetics to the commercial segment.

Cellular fuel gauge. The AMP-activated protein kinases (AMPK) are central components of a signal transduction cascade which functions as a metabolic sensor or "fuel gauge" in eukaryotic cells. When mammalian cells are subjected to stresses which act to deplete energy stores, the AMPK complex acts to downregulate energetically costly pathways such as cholesterol and fatty acid synthesis. AMPK consists of catalytic "a", and non-catalytic "b" and "g" subunits, and mammalian genomes typically contain multiple genes for each subunit. Although considerable work has been carried out on the human and rodent AMPK gene/enzyme systems, bovine AMPK genes have so far remained unexplored. Over the past year, primary sequence information for five bovine AMPK loci have been derived, and the molecular characterization of these genes is currently being completed. The ultimate goal of this study is to define the functional role of bovine AMPK genes and the AMPK protein complex in the regulation of energy metabolism, thereby gaining new insights into factors affecting energy efficiency in beef cattle.

Livestock economics

Transforming research into profitability

Canada's continued success in high quality beef production depends not only on research and development, but on the ability to translate that technology into marketable economic benefits. Livestock economics studies examine the value of genetics and physiology strategies in beef production systems.

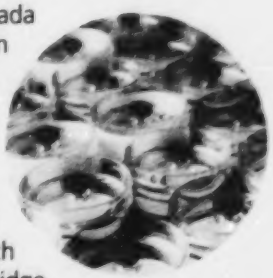
Economically-important traits. This ongoing study updated the economic potential of various genetic improvement strategies. Computer simulation was used to analyze new reproductive and performance-predicting technologies such as molecular marker assisted selection, ultrasound imaging and meat quality probes. The data will help develop procedures for economically-important beef production and product traits.

Estrus synchronization. This study found that recently developed estrus synchronization/artificial insemination (AI) regimes, which control *corpus luteum* and follical growth, returned $30-40 per cow exposed over natural service. By comparison, more classical AI regimes are only marginally profitable. Estrus synchronization is profitable only if the costs of synchronization and AI are offset by improved revenues from increased weaning rates (from a reduction in the length of the calving season), more calves produced and fewer bulls required.

Hormone, blood effects. In one study, the relationship between circulating adrenal and thyroid hormones and calf growth rate was determined to analyze the economic benefits of treatment. In a new study with lambs and calves, research will determine the relationship between plasma somatomedin and rates of growth and nutrient partitioning.

Biocontrol

Integrated strategies for sustainable control



The Centre has a cross-Canada mandate for research in weed biocontrol using insects and also explores other forms of this sustainable control alternative. A key focus is the protection of forages from rangeland weeds, research that is part of the Lethbridge Research Centre's national mandate for beef production systems. Weeds in cultivated fields are another major target.

Pathogens for disease control. Researchers screened many pathogens for their impact on the blossom blight disease of alfalfa and the damping off disease found in pulse, oilseed and sugarbeet crops. The most effective pathogens were selected and will be investigated to determine their potential for controlling these diseases.

Improving biocontrol with soil amendments. Work continues on the effect of different crop residues and formulated compounds (composted manure and other agricultural wastes) on the survival of soilborne pathogens and beneficial organisms.

Battling leafy spurge. The Centre and southern Alberta's Blood Tribe continue their joint effort to control leafy spurge, a noxious weed that has spread to about 8,000 acres on the Tribe's reserve. The plan uses insects that feed on the weed as biocontrol agents in addition to control efforts by the Tribe using sheep and chemicals. Agents include the black-dotted beetle, the brown-dotted beetle and two flat-back beetle species. The long-term project will help the Tribe reduce leafy spurge to tolerable levels and provide valuable information for the weed biocontrol program.

Restoring native species. Scientists continue to investigate the use of biocontrol as a management tool for restoring native plant species to rangeland. Many introduced weeds

compete better than native plants and have taken over portions of the land base, but biocontrol gives researchers a tool to help reclaim that territory. Ongoing studies target foreign weeds such as knapweed and spurge.

Targeting hound's tongue. Controlling hound's tongue using a European weevil remains the focus of this biocontrol study. This plant, a noxious weed that infests over 2000 hectares in Alberta's southern region, has become a serious problem for cattle producers. The weed hinders forage establishment, its burrs irritate cattle and can reduce their market value, and its high toxicity can cause poisoning. In Europe, where the weed originates, the weevil larvae that feed on hound's tongue roots show good potential for the long-term control of the North American problem.

Pathogens target pests. Research continues to explore the use of pathogens for biocontrol of the pest insects of rangeland, cereal crops and potatoes. This control option is becoming increasingly important for environmentally sustainable agriculture.

Integrating biocontrol into grasshopper strategy. Scientists worked toward new biological controls for grasshoppers as a way to reduce crop damage inexpensively without harming the environment. A suite of natural controls – including parasites, predators, microbes and microbe derivatives – shows great promise as a component of integrated grasshopper management strategies.

Dalmatian toadflax control showing impact. A stem-boring weevil introduced from Europe to Canada in 1991 to battle Dalmatian toadflax on western rangelands is beginning to show impact on its host. The majority of releases made in British Columbia have established successfully and monitoring of weevil populations indicates significant increases in the numbers of weevils at sites. In spring, emerging adults feeding near insect release points can severely stunt and prevent flowering of Dalmatian toadflax shoots. Continued monitoring of weevil impact on toadflax density is planned for 2000.

Range management

Balancing rangeland resources

Protecting western Canada's rangeland is essential to the future of the ranching industry and important to society as a whole. Researchers in the range management program are developing technology to help maintain that resource as demands on the land increase. Field studies and experiments continue to pursue an optimal balance for rangeland's many uses.

New information on poisonous plants. The program is expanding and updating a bulletin on "Stock-poisoning Plants of Western Canada," which outlines practical measures for the prevention of poisoning.

Detoxifying larkspur alkaloids. This study was initiated to develop *in vitro* procedures to assay for the potential for detoxification of larkspur alkaloids by rumen microbes. Tall larkspur in the foothills is a major cause of livestock poisoning; methods to prevent or minimize its damage are needed. With low larkspur, low alkaloid levels appear to be associated with plants growing on topographies with enhanced soil moisture conditions. Conversely, high alkaloid levels are promoted under conditions of soil moisture stress. These results indicate that, in addition to growth stage, it may be possible to predict the toxicity of alkaloid-containing plants by understanding the physical features of their growing site and how the habitat influences soil moisture availability.

Using biosolids to reclaim mine tailings. A field experiment using biosolids from the Greater Vancouver Regional District was initiated in 1999 to establish a permanent vegetative cover for very sandy mine tailings. The main objective of this work is to determine the impacts of fertilizer and biosolids amendments on the soil's physical, chemical and microbiological properties. Of concern at the study site is the high level of copper and molybdenum already present in the tailings and the additional inputs of metals from the biosolids applications. The health risk of these metals, especially molybdenum, to cattle and wildlife grazing the site are of concern, as is the potential entry of these elements into the food web. Also a priority is the establishment of vegetation that does not require annual inputs on land used for grazing.

Cattle grazing of forested clear-cut ranges does not compact soil. Cattle grazing forest plantations is common in Canada's western region. Soil compaction can occur following grazing and this is expected to vary with stocking rate, vegetation type, soil type, soil water content and climate. Soil compaction was evaluated before and after grazing over two years on soils from replanted clearcuts that had also been seeded to forage for eight years. While the presence of cattle grazing did increase soil bulk density and penetrometer resistance, these parameters were well below the critical ranges considered to limit root growth. Researchers determined that even when soils with moderate to high compaction ratings are grazed, it is unlikely that soil compaction will inhibit forest seedling growth.

Protecting riparian areas. This ongoing research will determine whether providing cattle with alternative water sources can reduce the need to fence off streams, ponds and creeks to protect those areas. Protection of these riparian areas is increasingly important.

Determining cattle diets. It is difficult to objectively measure which plants cattle eat when grazing. This study was initiated to develop a measurement method for grazing, based on the variability of plant alkanes, the waxy hydrocarbons on the plant surface which act like fingerprints.

Impacts of cattle on a grassland community. Researchers began work to determine what effect the removal of large cattle populations has on the soils and vegetation of the mixed prairie ecosystem in southern Alberta. The research will compare areas that haven't been grazed since 1927 with areas currently grazed, as part of an overall effort to develop a better understanding of the role of cattle in maintaining grasslands.

Tree encroachment on grasslands. Continuing work will determine the rate of tree encroachment onto grasslands in the interior of British Columbia. Scientists will also examine

the relationship between tree encroachment and environmental factors such as slope, aspect and elevation, as well as fire and grazing history. This will help predict the risk of encroachment and provide control strategies.

Soil-plant interaction. This project continues to examine the effects of organic compounds leached from plant roots into the soil. These compounds may trigger a sort of "chemical warfare" that prevents other plants from establishing. The results will help specify the effect of vegetation changes on soil and the long-term implications.

Effect of agriculture on native forage production and soil quality. Over 70 percent of the northern great plains are now cultivated with cereals and forages, but little is known about the effects of that production on native prairie soils. This study compared the relationship between different agronomic systems on different soil types in southern Alberta to generate knowledge for land management strategies.

Insects and ecology. Researchers determined the indirect impact of insecticide on grassland bird survival and recruitment. Bird and insect populations were monitored before and after spraying to determine the impact of grasshopper insecticide on food availability and utilization. The data will be used to determine a level of adequate pest control while preventing environmental damage.

Insect forecasting. To improve forecasting, data studies determined the influence of body size, orientation and microclimate on the body temperature of grasshoppers. Other ongoing studies will lead to improved forecasting for various insects over large areas.

Onefour grazing studies. A study to be conducted at the Onefour Ranch will examine the effects of extended grazing seasons on cattle performance and the condition of native mixed grass prairie. Testing will determine (1) whether fall feeding treatments influence cattle performance in the post-weaning, pre-winter period (2) the impact of fall grazing on the condition of native grassland (3) the effects of grazing heterogeneity on pasture condition and wildlife habitat resulting from extensive grazing.

Water and air quality

Benchmarks for industry responsibility

Technology, mechanization and crop protection advances have resulted in rapid agricultural change over the past several decades. Productivity has improved dramatically, but several environmental concerns have emerged. Researchers are addressing water quality concerns and helping western Canada achieve a harmony between highly efficient agricultural production and environmental protection.

Contamination risks from ranching. A water quality study near Kamloops is determining water quality parameters at five sites to assess water quality changes due to ranching activities. Factors under evaluation include water quality parameters such as bacteria (fecal coliform and fecal streptococci), pathogens (*giardia* and *cryptosporidium*), nutrients (nitrogen and phosphorus), temperature (water, soil and air), turbidity, pH and oxygen. These factors will be evaluated in relation to livestock access, distributions and densities compared to the source water and runoff. Information will be used to inform the ranching industry on the environmental impact and provide recommendations for reducing the risk of water contamination.

Herbicide sustainability. Researchers are continuing this long-term study to develop improved herbicide management strategies. The goal is to balance the needs of crop production with environmental and human health concerns. First phase results compared the runoff of herbicides and nutrients into small water bodies under different tillage systems, determined the impact of conservation tillage systems on soil, air and water quality and determined the effects of wind erosion on herbicide transport.

Water studies in Saskatchewan. The Centre continues its collaboration with Saskatchewan researchers on several herbicide studies. They are looking at nutrient and herbicide inputs in the South Saskatchewan River from the Outlook Irrigation District, are developing methods of measuring vapor losses and are evaluating methods of reducing vapor losses.

Cutting nitrogen losses in cattle. Scientists developed a new precision approach to protein feeding that can substantially cut nitrogen losses in beef and dairy cattle. The research potential extends beyond the farm base. By increasing cattle nitrogen retention, not only is manure nitrogen lowered for better balanced fertilizer, the potential for volatile urea releases to the atmosphere is also dramatically lowered. The approach has two steps: to maximize rumen microbial protein synthesis and to meet additional protein requirements using a well balanced protein supplement which meets the specific amino acid needs of cattle.

Weight gain fluctuations linked to water source, quality. Results from this ongoing study indicate that where cattle get their water and the quality of that water may have a dramatic impact on weight gain performance. It has long been assumed that as long as cattle have access to an adequate water supply, the only variable that affects their performance is feed, but these results suggest water intake factors are significantly underestimated.

Exploring beef/water/human health links. This continuing study will determine if beef cattle are potential sources of giardiasis and cryptosporidiosis. Although transmission of the organisms from cattle to humans has not been scientifically proven, cattle have been blamed for outbreaks. Because of the potential of these organisms to infect humans and their potential to negatively impact beef production, scientists hope to uncover the facts about transmission and, if necessary, develop methods for their control. The first phase will determine prevalence of the associated diseases by looking at samples from cow-calf and feedlot operations at strategic locations.

Oldman Basin water quality initiative. The Oldman Basin represents the most intensive agricultural area in Alberta. Water quality in the basin is of increasing concern, as agricultural and food processing industries continue to expand. A water quality specialist has been hired to determine the impact of agricultural practices on water quality and to

implement beneficial management practices (BMPs) to protect water quality. This project will focus on determining BMPs for manure management in the Battersea Drain Watershed, as well as protecting riparian areas in the Little Bow Watershed.

Controlling atmospheric emissions from feedlots. A new initiative explores how ammonia emissions from feedlots can be reduced. By measuring the emissions, determining their impact on crop growth and looking at methods of emission reduction, scientists are working to improve the sustainability of intensive livestock operations.

Herbicide leaching. Researchers evaluated the results of a study that examined the leaching of six herbicides on soils near Lethbridge and Lacombe. All leached more readily in the dark brown soil zone around Lethbridge, which has less soil organic matter than the black soil zone around Lacombe. Factors such as amount and size of soil pores were a major influence on leaching. Also, each herbicide's soil persistence and tendency to adsorb to soil varied between each soil type. Laboratory tests suggest that allowing herbicide residues to adsorb to dried soil before irrigation would significantly reduce herbicide leaching.

Odour control. Scientists continued ongoing efforts to develop strategies for manure application. A major component of the study was periodical monitoring of ammonia concentrations downwind from feedlots. Odour management experiments showed that significant control of odour-producing components is possible with relatively simple management practices immediately following manure application.

Nitrous oxide emissions. The potential of crops such as barley and canola to manage nitrous oxide emissions from agricultural lands is being examined in this ongoing study. Researchers are also determining the effect of chinook winds on the emissions.

Impact of feedlot manure on water quality and human health. A three year study funded by the beef industry is continuing to determine the impact of intensive beef feedlots and their associated manure production on water quality and human health. The focus is on nutrients such as nitrogen and phosphorus, soluble salts, and bacteria such as *E. coli*. The quantity and quality of runoff from feedlot pens is being determined, as well as the impact of the feedlots on groundwater quality. Persistence of bacteria in feedlot pens, catch basins, and compost windrows is also being determined. The environmental sustainability of fresh manure versus compost is also being assessed by field experiments.

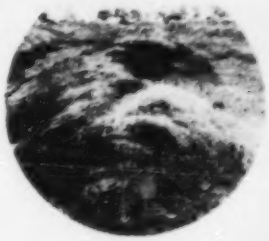
Tillage effects on leaching. Data was examined from a major research effort on the physical and hydrological properties of soils under conventional tillage and no-till. A completed two-year study examined unsaturated water flow under conventional tillage, minimum tillage and no-till systems. Another study determined leaching of chemicals in water under conventional tillage and no-till. The effort also examined preferential flow in macropores such as earthworm burrows and root channels under these tillage systems. Macropores are the major pathways for leaching into groundwater.

Long-term impact of manure application. Preliminary results of soil studies showed large pores caused by soil cracks, old root channels or earthworm burrows are extremely important in preferential leaching of water and chemicals through the plant root zone, and can have a major impact on groundwater quality. Manure appeared to increase water infiltration at high water potentials (into larger pores), but appeared to inhibit water infiltration at lower water potentials (into smaller pores). Also, higher manure rates generally led to higher soil moisture.

Manure management

Resource vs waste

The rapid intensification of livestock production on the prairies has been accompanied by a growing need to address the issue of animal manure. Manure is beneficial to crops when applied at appropriate rates, but can create soil, water and air quality problems when over-applied. Scientists are pursuing ways to not only manage that resource, but to take advantage of its nutrient value.



Long-term studies. The Centre's long-term manure plots established in 1973 continue to provide valuable data for the sustainable use of manure in cropping systems. Researchers continue to monitor the plots to determine changes in soils as affected by various application rates of fresh manure.

Reducing volatilization losses. Scientists continue to study nitrous oxide emissions from soil treated with various high rates of feedlot cattle manure, to determine correlations between volatilization rates and environmental factors such as temperature and soil moisture. The study is part of an effort to develop methods to control nitrogen losses from manure during storage, and to explore composting and land application methods that conserve nutrients and reduce environmental impact.

Impact of manure phosphorus. Manure is generally applied at rates to meet the nitrogen requirements of crops, but researchers have recognized the potential benefits of phosphorus-based applications. Nitrogen-based strategies leave potential for a build-up of phosphorus at the soil surface, which is capable of contaminating surface water by runoff. To reduce the effects of "P-loading," researchers are evaluating the environmental impact of this input. Laboratory studies continue to assess the potential salinity and P-loading problems after repeated applications of fresh feedlot manure.

Rebuilding eroded soils. Researchers assessed the potential of manure to restore the productivity of artificially eroded soils and decommissioned oil and gas well sites. The initiative is part of a larger Centre effort to use various organic amendments as tools for rebuilding degraded or disturbed soils.

Composting as value-added. This project examines how nutrient concentrations in manure change due to composting. The goal is to evaluate the economics of composted manure as a value-added product and develop management strategies. Since fresh manure hauled to the field contains 60 percent or more water, composting can significantly lower transportation costs.

Soil management

The new sustainable agriculture

Land use planning and management has always had a major influence on agriculture, but science has shown the implications extend far beyond the farm base. Researchers are working to unlock further secrets of how natural processes work within soils. Armed with that knowledge, they can look at a range of land use issues ranging from building better production systems to improving the environment. The goal is to produce land management systems that ensure the sustainability of agricultural and non-agricultural ecosystems.

Carbon cycling. Scientists continue to study the exchange of soil carbon dioxide, the major greenhouse gas targeted in the Kyoto agreement. Since the pool of carbon within soils is three times that in plants and twice the amount in the atmosphere, agricultural production can have a major impact on the earth's carbon cycle. Scientists are investigating the potential of using agricultural lands as a sink for storing excess carbon dioxide from the atmosphere.

Low input grassy weed control. This study examined the effects of VAM fungi on grassy weeds as a potential biocontrol method. It's part of a larger effort to learn about biological activity in agricultural ecosystems so that strategies can be developed to improve soil health and productivity while reducing reliance on external inputs.

Atmospheric fluxes. Several studies measured atmospheric fluxes on agricultural lands. The data will be used to develop methods of reducing carbon and nitrogen losses to the atmosphere to improve soil quality, crop growth and environmental quality. One study compared soil respiration under different management regimes. Other studies examined the impact of tillage on short-term carbon dioxide emission, monitored the rate of ammonia absorption by soils from feedlot manure, determined the impact of ultraviolet rays on the decomposition of wheat straw, evaluated the effects of tillage and nitrogen fertility on the breakdown of cereal residues under irrigation, and developed a forecasting model to predict soil respiration.

Sustainable weed control. Researchers continue to pursue weed control measures for prairie cropping systems that maintain crop yield, reduce input costs and minimize environmental impact. A series of field studies evaluated experimental herbicides and herbicide application methods and explored sustainable weed control methods for reduced tillage systems. Control methods include cultural practices such as plant residue management, optimum timing and placement of fertilizer and manure to manage weeds and increase yields, use of cover crops, and various integrated management systems. The performance of a weed-sensing sprayer was also evaluated in conservation fallow and cropping systems.

Soil restoration. A long-term study was completed to determine the changes in crop yield and soil quality after artificial erosion. The results will contribute to development of methods that restore the biological, physical and chemical properties of soils damaged by erosion, disturbance, or degradative management practices.

Precision farming. Further work will explore the potential of new satellite technology that could lead to improvements in sustainable production. Researchers are evaluating the potential of related technology to monitor agricultural practices from satellites, developing a baseline map of soil conservation practices on the prairies, evaluating the potential of remote sensing for range management, and setting up a field program to identify the role of remote sensing for precision farming systems in southern Alberta. Precision mapping will allow farmers to target inputs to small areas of land. The technology will also enable researchers to assess the adoption of conservation measures and develop strategies for sustainable soil management.

Remote sensing space project. The Centre contributed remote sensing expertise to a major United States-based agricultural venture. Plans for the ongoing initiative are to launch in 2001, four satellites equipped with remote sensing capability to take repeated "snapshots" of the earth's surface and to use this information to build products that provide information on soils, crop vigor and plant stand.

Long-term plots. Since changes in land due to management practices occur over decades, the Centre has an invaluable resource in its long-term crop research plots, some of which date back to 1910. Researchers continue to monitor the plots to determine the eventual impact of current and experimental cropping practices on soils and adjacent environments. In addition to continuing dryland, irrigation, tillage, carbon cycling and other long-term studies, scientists established a baseline for a new long-term low-input rotation, and began the development of an economic computer model to predict the effect of climate change on cropping practices and carbon release.

Worm Watch biodiversity program. Worm Watch - a program to collect data on the biodiversity of earthworms across Canada – was further developed. The program sparked national attention for its dramatic potential as a tool for science education and for the development of indicators for soil health and quality. Worm Watch has been recognized as a "Canadian contribution to the UNESCO program, Man and the Biosphere," by the program's Canadian branch. It is also one of Canada's contributions to the program on agricultural biodiversity under the International Convention on Biological Diversity.

Earthworms as soil managers. Research showed improved wheat yield and some lessening of clubbing and stunting when earthworms were included in treatments inoculated with 'take-all'. Previous studies showed earthworms generally favor zero-tillage environments and are effective residue and disease managers under no-till. Results indicate earthworms contribute to a significant decrease in surface residues.

Native plant potential for land reclamation and production. Public demand to use native plant material means agriculture needs information on species productivity and performance in mixes. Continuing studies evaluate the impact of heterogeneity among native and introduced stands on forage production and soil quality. Several plants show promise for reclamation, wildlife habitat, forage and improved soil quality.

Sustainability project in Lowland China. Scientists continue to collaborate with Chinese researchers on the Hebei Dryland Project, a program sponsored by the Canadian International Development Agency (CIDA) to improve farming practices in the nation's Hebei Lowland region. The current five-year phase focuses on sustainable farming practices. Lethbridge researchers use their background in sustainability and dryland farming to help train Chinese researchers and advise them on individual research areas. A previous five-year phase focused on improving crop yields.

Monitoring Alberta soil change. A continuing study monitors changes in soil quality at benchmark sites across Alberta. The results will help assess agricultural sustainability in the province and contribute to land management strategies.

Soil database. A completed four-year project resulted in a standardized digital database of agricultural soil landscapes in Alberta. The Agricultural Region of Alberta Soil Inventory Database (AGRASID), published on compact disc, can be used with GIS to generate maps for land-use planning and to plan farming systems.

Balancing crop production, soil conservation. Research looked at effects of tillage and crop rotation on crop yield and quality, and on the soil's physical and chemical properties. Preliminary results indicate that crop yields and soil properties under conservation tillage are similar to those under conventional tillage.

Input strategies to battle erosion. Results show that inorganic fertilizers are not cost-efficient tools for improving soils with high levels of erosion, even at high grain prices and low fertilizer costs. Using organic matter to improve soils looks more promising, but depends on soil properties, fertilizer use and climatic conditions. An ongoing study targets economic strategies.

Potatoes

Industry-driven progress

Researchers continue with innovative approaches to develop disease resistant, high quality potato cultivars and germplasm for western Canada. The program has a heavy industry-driven, high-tech flavor, and is backed by research in sustainable disease and insect control strategies.

Release of new variety, AC Glacier Chip. The new variety has a high yield combined with excellent chipping quality and agronomic characteristics superior to Snowden, the main crop variety currently grown for chip manufacture in North America. In trials conducted in Alberta, AC Glacier Chip out-yielded Snowden by 14-43 percent. Unlike Snowden, the tubers are concentrated in the hill, which facilitates harvest. The new variety maintains excellent chip quality in long-term storage. Similar to Snowden, the new variety is moderately resistant to early blight but moderately susceptible to common scab and verticillium wilt. Management studies indicate that the new variety should be grown with an in-row spacing of 30 cm. Yield responses to nitrogen measured up to 240 kg/ha.

Release of new variety, AC Maple Gold. This new variety with yellow flesh is suitable for manufacture into french fries and can also supply the fresh market niche for yellow flesh. This is the first Canadian-bred yellow-flesh french fry variety and provides the industry with a dual-purpose yellow-fleshed variety that can be harvested early (80 days after planting) or stored for long periods of time without suffering deterioration in processing quality. Marketable yields are similar to Russet Burbank but tuber size is smaller. The new variety is resistant to fusarium wilt, moderately resistant to early blight, moderately susceptible to common scab and susceptible to verticillium wilt. Management studies indicate that the new variety should be grown with in-row spacing of 30 cm. Yield responses to nitrogen measured up to 240 kg/ha.

Consortia boosts variety development. The program continues its industry-driven initiative with the Western Canadian Potato Breeding Consortium. The original three-year Consortium pilot project, which produced 14 variety clones adopted by industry, is in the second year of a renewed five year project. It is based on agreement between multiple industry partners and the Centre, whereby the partners evaluate, promote and market products produced by the potato program in exchange for first right of refusal on those varieties. The first project, which focused on classical breeding, is now known as Consortium "A." The second project, Consortium "B," was added as a five-year project to focus on breeding using biotechnology. The overall objective of the Consortia is to improve the introduction of varieties for the western Canadian potato industry. Ongoing studies target improved varieties for the french fry and chipping markets.

Colorado potato beetle control. Researchers continue to develop an insecticide resistance management program for the Colorado potato beetle, the most destructive insect pest of potatoes worldwide. The goal is to help western Canada avoid the buildup of resistance to commonly-used chemical control products that has occurred elsewhere in the world and to develop alternative controls. For the first phase of the project, scientists are studying the phenology (life cycle, movement within the crop, overwintering habits, etc.) of the beetle in western Canada. As an alternative control strategy, they are also studying the effectiveness of a naturally occurring fungus that is a pathogen of the potato beetle with potential to decimate beetle populations.

Agronomy packages. Phase one of an initiative to provide management packages for advanced breeding material was completed. Researchers conducted spacing, nitrogen fertilization and bruise susceptibility studies to develop potato clones with commercial potential.

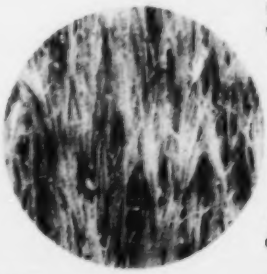
Strategies for control of bacterial diseases. There are no effective chemical controls for bacterial outbreaks in the field or in storage. Novel tactics are now employed to monitor and control bacterial diseases. These include screening wild potato species for new sources of resistance to blackleg disease, which causes approximately $32 million in damage to Alberta potato crops each year. Newly identified resistance will be incorporated into new potato varieties, broadening the genetic diversity of resistance. Innovative ecological studies that employ bacteria-carrying special molecular tags will enable researchers to follow the bacteria as they travel through the environment and cause disease in the plant. Advances in molecular and immunological tests that detect low levels of pathogen populations in the field facilitate assessments of disease potential in the current and future crop seasons. Insight into how a disease initiates and spreads is crucial for development of effective control strategies.

Resistance genes reduce fungal disease. Verticillium wilt, late blight and dry rot cause enormous quality and yield losses. Scientists have identified Vc, the first single dominant gene from the genus *Solanum* which confers resistance to verticillium wilt. Closely linked DNA markers were developed for a related tomato gene to accelerate and accurately screen for resistance. These DNA markers are being used to isolate Ve and advance development of disease resistant crops. Similarly, genes conferring complete resistance to aggressive isolates of late blight have been identified in wild species of potato and the genetics of pesticide resistance to dry rot was characterized to develop management strategies that can reduce disease losses.

International collaboration to eliminate virus. The potato leafroll virus (PLRV) is responsible for alarming reductions in yield and quality. In collaboration with the Max Plank and Fraunhofer Institutes, Canadian and German full-length infectious cDNA (FLIC) PLRV clones are providing important new information on the virus through reverse genetics. For example, FLICs have already assisted in the identification and characterization of novel PLRV proteins such as P1-C25, which may provide new strategies for virus elimination.

Wheat

Reinventing western Canada's specialty wheats



As a western link in the vast Agriculture and Agri-Food Canada crop development network, the Lethbridge Research Centre targets two specialty wheats. Soft white spring wheat, a niche crop for irrigated areas in southern Alberta, has diverse market benefits. Winter wheat is a crop with exciting potential for wider adaptation.

New winter wheat for southern Alberta. A new high-quality winter wheat was developed and is expected to become the standard in the traditional growing areas of southern Alberta. AC Tempest out-yielded AC Readymade, the current standard, by an average of four percent over three years of testing. AC Tempest is very strong-strawed and high in protein, with improved grain yield compared to AC Readymade. It is also moderately resistant to bunt.

Pioneering "gene stacking" work. Scientists continue with pioneering work in gene stacking or pyramiding – a new approach to building disease resistance into crop cultivars which could lead to a new era of indomitable and long-lasting disease resistance. Many common crop pathogens, such as rust and bunt in wheat, mutate over time and eventually overcome individual sources of resistance. Gene stacking, or incorporating multiple sources of resistance into one variety, dramatically decreases the chances of that happening. Researchers developed new molecular markers for two wheat genes with resistance to bunt, making a stacked resistance approach possible.

Tapping winter wheat potential. It could be the perfect crop: very high yields, protein and quality along with early maturity and agronomic requirements well suited for the shift toward reduced tillage and sustainable rotations. But winter wheat requires careful management and specific adaptations. Researchers continue to work toward new varieties and strategies to meet those criteria. Ongoing studies concentrate on disease and agronomic advances to move winter wheat production into the central and northern prairies. Snow mold resistance and cold-hardiness are two current targets. Scientists identified material with both characteristics for use in the breeding program. Other studies will select for better resistance to common bunt.

Breeding technology. Several new breeding methods are being evaluated for efficiency, cost-effectiveness and suitability in the wheat development program. One study looks at the relative efficiency of anther culture and wide hybridization (wheat x corn) techniques in producing haploids of common wheat. Also, a marker linked to a stripe rust resistance gene has been identified. A new study will determine the influence of genotype and environment, and their interaction on the end-use quality of SWSW. The data will help develop cultivars that consistently produce high quality grain. Ongoing studies aim to: identify DNA markers for stripe rust resistance genes, evaluate the potential of microsatellite sequences for developing DNA "fingerprints", determine the chromosomal location of genetics controlling disease resistance in the wheat-alien hybrid line Agrotana, develop markers for bunt resistance to facilitate pyramiding of such genes, develop markers for snow mold resistance and freezing tolerance in winter wheat, and identify markers for potential chromosome substitution lines of hard red spring wheat cultivars.

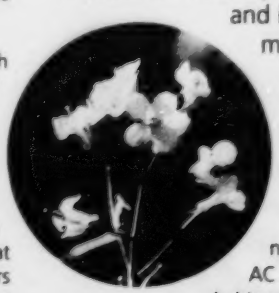
Diseases. Researchers have developed an inexpensive image analysis system for rapid and accurate quantification of grain diseases such as Fusarium Head Blight. Other ongoing activity aims to determine the influence of nitrogen fertilizer rates and seed treatments on disease severity in SWSW, and to select for bunt and stripe rust resistant cultivars of SWSW and winter wheat.

Agronomy. New studies are underway to determine the relationship between sugar composition or concentration with level of freezing tolerance or snow mold resistance. These studies also aim to determine the optimum date of seeding for cold-hardy, snow mold resistant winter wheat in central and northern Alberta.

Field crops

Sustainable field crop systems

A focus on new dry bean breeding technology and innovative weed and pest management strategies.



Breeding technology. Significant advances have been made in both wide and narrow row varieties. Dry beans were developed to permit narrow-row production. A new small red bean variety, AC Redbond, with an upright growth habit performs particularly well in narrow rows, permitting cereal and oilseed growers to become involved in this market class of bean. A great northern bean variety, AC Polaris, also particularly suited to narrow row production, was developed. Ongoing efforts are aimed at

developing improved upright dry bean varieties for a number of market classes adapted to the short growing season of western Canada.

Stork's bill. Researchers determined the effects of various densities of stork's bill and the various lengths of its interference on the yield of dry beans, field peas, canola, and soft white wheat. This will help growers predict when control measures are needed.

Disease resistence. Studies initiated in 1997 will select bean cultivars that show improved resistance to white mold and gray mold for use in the breeding program. One study will determine the yield and quality of potential upright lines of dry beans grown in commercial fields under natural stress of white mold.

Weed management. An experimental herbicide was tested for its potential to provide improved post-emergence selective control of grass and broadleaf weeds in dry beans, field peas and lentils. The herbicide showed potential and will be submitted for registration. Scientists continue to develop an improved weed management system for dry beans through cultural methods. They will also evaluate an improved weed management system for field peas. Another study will determine the correlation between weed growth rates and the dose of herbicide required for control. Finally, researchers aim to develop a weed management computer module for forecasting.

Insects. The insect pest management research program in canola was started at the Centre in 1999. Researchers are concentrating on management of lygus bugs and cabbage seedpod weevils by developing integrated pest management practices. Scientists are undertaking studies of the spatial distribution of these insects and field and laboratory studies of their overwintering biology. Economic thresholds for pest combinations will be developed using cage studies to determine impacts of insects on canola yield and chemical spray trials in plots. A farm scale study will test the possibility of trapping the cabbage seedpod weevil in commercial canola fields.

Forage

Fundamentals for growth

The western forage industry is in a growth phase, thanks to an expanding cattle industry across the west, a new prominence of forages as cash crops with value-added potential, and growing recognition of forages' agronomic benefits. The forage program is pursuing strategies to help meet the evolving research needs of that industry.

Bloat-safe grazing of alfalfa. Research at Agriculture and Agri-Food Canada Centres in Lethbridge, Kamloops, Lacombe, and Saskatoon continued work towards a bloat-safe grazing system for alfalfa. Previously, researchers announced the release of AC Grazeland, which will be an important part of the "tool box" of technologies that will lead to bloat-safe alfalfa grazing. Researchers are now looking at mixed pastures of AC Grazeland and sainfoin (a legume known to be bloat-safe), to provide additional bloat protection for cattle, without reducing the productivity of legume pastures. Further work is examining the use of pluronic detergents to prevent bloating. Results from studies at Kamloops, Lethbridge, and Lacombe showed that one of these compounds was 100 percent effective in preventing bloat in cattle grazing on alfalfa pastures; researchers are pursuing registration in Canada.

Alfalfa varieties. Alfalfa variety AC Longview (tested as LRS 93-1) was approved for registration. It adds to previously registered varieties Barrier and AC Blue J – all part of the forage program's disease control effort. All three cultivars are resistant to bacterial wilt and verticillium wilt, the main disease threats for alfalfa in irrigated areas of western Canada. The varieties yield well under irrigation and are long-lived because of their superior adaptation characteristics and disease resistance. AC Blue J and AC Longview also perform well on dryland. Scientists are working on strategies to reduce bloat in these disease resistant cultivars.

Alfalfa as sustainability tool. Scientists are continuing this project which measures the water uptake potential of various types of alfalfa. The plan is to identify alfalfa material that can serve a purification role in farming by protecting groundwater quality. Because alfalfa uses high levels of water, it has potential to draw down the water table - which can help prevent leaching of chemicals, reduce salinity and restrict the movement of feedlot wastes containing nitrates and urea.

Perennial cereal rye. Research continued on perennial cereal rye, which shows many advantages over barley as a silage crop. This forage matures a few weeks earlier than barley, but has almost identical yields and nutritional quality. The crop persists for several years, takes advantage of spring moisture and has good regrowth for a second cut of hay or pasture. But the crop has some hurdles to cross. Because it is a hybrid of two distinct species, it produces many sterile flowers. Its extended flowering period makes the crop vulnerable to seed-borne diseases such as ergot. Scientists are working to reduce the sterility level and develop strategies for maximizing forage and seed yield.

Fenugreek. Scientists discovered that this crop, new to Canada, has exciting potential as an alfalfa alternative. The high-protein legume, traditionally grown in India and other countries, makes good silage and is a natural source of valuable steroids that may increase muscle development. Like alfalfa, this high-quality legume fixes nitrogen in the soil. While alfalfa is a perennial, fenugreek is an annual crop. It has slightly less dry matter and protein, but is relatively equal in terms of nutritional quality for cattle and holds its quality after blooming, giving producers more flexibility for harvest. Preliminary experiments also suggested fenugreek may be bloat-safe.

Superior cicer milkvetch variety. Scientists dramatically improved yield potential for cicer milkvetch with a new variety, AC Oxley II, making the crop an ideal pasture legume. In western Canadian forage trials, the new cultivar yielded 50 percent more in the establishment year than Oxley, the current standard variety. Cicer milkvetch has been a neglected legume with good potential, especially for grazing, and scientists are now tapping the crop's potential. The new variety was bred specifically to eliminate seedling vigor problems. Results show it is long-lived, nonbloating, grows well, has no serious diseases or insect pests; as well, pocket gophers leave it alone and cattle readily graze it. The legume yields five to six tons of dry matter per acre under irrigation, about the same as alfalfa in a two-cut system, but less than alfalfa in a three-cut system.

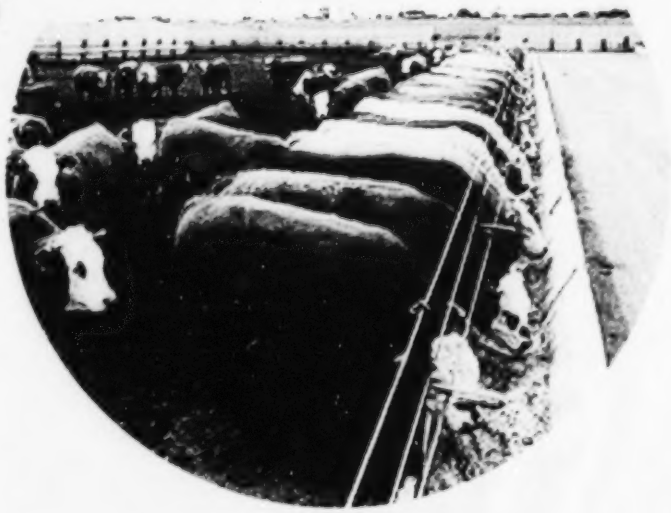
Agronomy initiative. With alfalfa's disease resistance goals achieved, researchers are focusing on development of cultivars and strategies that produce high yields over many years under difficult conditions. The goal is to develop stands and management techniques so alfalfa can compete well with grasses and perform better on acid soils and areas of long term grazing. Most commercially-available alfalfa varieties were developed in pure stands and were not selected for their ability to compete with grasses. Researchers are working on ways to manage mixed stands so that grasses do not overwhelm the alfalfa. They are searching for alfalfa genetic material adapted to the competitive environment of a mixed forage stand, and for other materials for the program's new direction, such as plants from very old stands on acid soil, stands that competed well with grasses, as well as stands that have withstood long-term grazing.

Blossom blight disease. A study on the blossom blight pathogen showed how the disease infects plants and how it affects pod development, seed yield and seed quality. The results will lead toward control measures against this disease.

Weed management for new forages. Field studies continue to assess herbicide and management techniques for controlling weeds in fenugreek and perennial rye. Initial results showed fenugreek yield increased up to 79 percent with appropriate herbicides. Perennial rye showed good competitiveness with weeds and seemed to tolerate all of the herbicides registered for fall rye.

Intercropping annual barley, annual ryegrass and annual legumes. A study at the Kamloops, B.C., Range Research Unit shows that intercropping annual legumes with annual barley and annual ryegrass can improve forage yield and quality.

British Columbia agronomy. Several studies are part of an ongoing effort to develop improved cultural practices for sustainable forage production in the interior of British Columbia.



Lethbridge Research Centre Staff

Management
Steve Morgan Jones, Director
Peter Burnett, Assistant Director
Glenn Coulter, Assistant Director

Livestock Sciences
Brian Freeze, Section Head
Kevin Floate, Assistant Section Head
Livestock Pest Biological Control
Zahir Mir, Assistant Section Head,
Ruminant Nutrition
John Baah, Feed Biotechnology and Nutrition
Danica Baines, Insect Ecology
Reem Barakat, Microbiology
Karen Beauchemin, Ruminant Nutrition
Bernhard Benkel, Molecular Genetics
Sylvie Bilodeau-Goeseels, Embryology
Nicolas Caron, Genetics
Doug Colwell, Ruminant Parasitology
Denny Crews, Genetics
Helen Fairweather,
Agricultural Systems Modelling
Bob Forster, Rumen Biotechnology
Mike Ivan, Nutritional Physiology
Sushil Jacob John, Molecular Biology
John Kastelic,
Ruminant Reproductive Physiology
Bob Kemp, Genetics
Karen Koenig, Ruminant Nutrition
Eric Kokko, Electron Microscopy
and Image Analysis
Fran Leggett, Electron Microscopy
and Image Analysis
Tim Lysyk, Insect Ecology
Tim McAllister, Rumen Microbiology
and Nutrition
Gerry Mears, Biochemistry-Physiology
Priya Mir, Animal Physiology and Nutrition
Diego Morgavi, Ruminant Nutrition
and Microbiology
Pius Mwansa, Genetics
Ron Teather, Rumen Biotechnology
Yuxi Wang, Rumen Microbiology and Nutrition
Marc Whitford, Rumen Biotechnology
Jianping Xu, Enyzmology
Wen Zhu Yang, Ruminant Nutrition
Jay Yanke, Bacteriology

Land Resource Sciences
Rick Butts, Section Head
Frank Larney, Assistant Section Head,
Soil Conservation
Wole Akinremi, Agroecosystem Modelling
Chi Chang, CIDA Project Coordinator
Jill Clapperton, Rhizosphere Ecology
John Dormaar, Organic Chemistry (*Emeritus*)
Ben Ellert, Carbon Cycling
Toby Entz, Statistics
Xiying Hao, Soil Physics
Henry Janzen, Soil Biochemistry
Dan Johnson, Rangeland Insect Ecology
Joanne Little, Water Quality Specialist
Sean McGinn, Agrometeorology
Jim Miller, Soil & Water Specialist
Anita Shepherd, Crop Modelling
Anne Smith, Remote Sensing
Elwin Smith, Bioeconomics
Walter Willms, Range Ecology
John Wilmshurst, Range Ecology

Kamloops Range Research Unit
Doug Veira, Site Manager, Animal Behavior
Yuguang Bai, Tree Encroachment
Klaas Broersma, Soil Science
Walter Majak, Range Plant Biochemistry
Don Thompson, Range Plant Physiology

Crop Sciences
Jeff Stewart, Section Head
Bob Blackshaw, Assistant Section Head,
Cereal and Special Crop Weeds
Surya Acharya, Forage Breeding
Sylvie Bardin, Field Crop Diseases
Rob Bourchier, Insect Ecology/Weed Biocontrol
Bob Byers, Honorary Research Associate
Hector Cárcamo, Insect Pest Management
Qin Chen, Molecular Cytogenetics
Bob Conner, Cereal Diseases
Rosemarie De Clerck-Floate, Weed Biocontrol
Francois Eudes, *In Vitro* Culture
Debbie Fujimoto, Molecular Bacteriologist
Dennis Gaudet, Cereal Diseases
Mark Goettel, Insect Pathology
Rob Graf, Winter Wheat Breeding
Peter Harris, Weed Biocontrol (*Emeritus*)
Bernie Hill, Environmental Chemistry
Henry Huang, Forage Crop Diseases
Larry Kawchuk, Molecular Pathologist
Andre Laroche, Wheat Molecular Genetics
Guo Qing Li, Crop Diseases
Hongjie Li, Wheat Cytogenetics
John Lu, DNA Fingerprinting
Dermot Lynch, Potato Breeding
Jim Moyer, Forage Weeds
Hans-Henning Mündel, Bean Breeding
Christine Noronha, Entomology
Cory Nykiforuk, Molecular Biologist
Brian Orshinsky, Forage Cytogenetics
Sadash Sadasivaiah, Soft White Spring
Wheat Breeding
Hai Su, Plant Pathology

Administration
Marc Parent, Head, Administration
Tracy Lund, Systems Manager
José Barbieri, Acting Communications
Coordinator
Ken Lievers, Commercialization Officer
Vince Barlow, Human Resources

Senior Supervisors
Brian Beres, Head of Agronomy Unit, Crops
Brian Farries, Field Operations, Land
Tom Kveder, Head of Greenhouse, Phytotron &
Grounds, Crops
Larry Maio, Operations, Kamloops
Ian Walker, Ranch Manager, Onefour, Livestock
Terry Seely, Vivarium, Livestock
Graham Steacy, Farm Manager, Lethbridge,
Livestock

Centre Advisory Committee

Bryan Noble, AC Chair
Alberta Winter Wheat Producer's Commission

Harvey Brown
Ontario Cattlemen's Association

Sylvia Campbell
Southern Alberta Environmental Group

Dr. Ralph Christian
Alberta Agricultural Research Institute

Ray Grimson
Lakeside Farm Industries Ltd.

Spencer Hilton
Alberta Conservation Tillage Society

Lloyd Mercer
Seed grower

Dr. Stephen S. Moore
University of Alberta

Blair Roth
Special Crops Business Unit, Agricore

Richard Stamp
Seed and potato producer

Weldon Thomson
Rancher

Ex-officio Members

Dr. Bill Yates
Animal Diseases Research Institute

Dr. David Bailey
Lacombe Research Centre

Dr. Dennis Fitzpatrick
University of Lethbridge

Dr. Ron Howard
AAFRD

Don Young
AAFRD

Canada/Alberta Livestock Research Trust Inc.

Peter Schuld, President
Iron Springs, Alberta

Clarence Jones, Vice President
Dewinton, Alberta

Lance Carnine, Secretary-Treasurer
Lethbridge, Alberta

Fred van Ingen
Redwater, Alberta

Arno Doerksen
Gem, Alberta

Larry Helland
Lomond, Alberta

Dwight Karren, Executive-Manager
Lethbridge, Alberta

Dr. Brian Freeze, LSS Contact
Lethbridge Research Centre
Lethbridge, Alberta

Dr. Steve Morgan Jones, Director
Lethbridge Research Centre
Lethbridge, Alberta

Dr. Bill Yates, Director
Animal Diseases Research Institute
Lethbridge, Alberta

Canada

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

The Lethbridge Research Centre
Phone: (403) 327-4561